HEURISTICS METHOD FOR TRUCK DISASSEMBLY PROCESS

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I dedicate this dissertation to my family, especially…

to Dad and Mom for instilling the importance of hard work

and higher education;

to grandma and grandpa for encouragement;

to the families of Michelle Yeoh, Sean Yeoh, and May Yeoh-

may you also be motivated and encouraged to reach your dreams.

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ABSTRACT

Product recovery is an interesting topic in nowadays especially in remanufacturing industries. Remanufacturers focus on product recovery because of some valuable parts can be used in remanufacturing processes. Disassembly is an important process that extract related valuable parts or subassemblies and materials from discarded products. The discarded products have high degree of uncertainty in the structure and the quality of the returned product. Some parts of the product may cause pollution or may be hazardous. Disassembly Line Balancing Problems (DLBP) is the main issue that remanufacturers have to solve it during disassembly processes. The objectives of this research is to optimize the workstation in a disassembly line and improve the utilization of each workstation by proposed heuristic rule. The Delmia Quest simulation software was used to validate the model between actual disassembly line and proposed heuristic rule. The model proposed apply heuristic rule to create better results compared to actual disassembly line in terms of environmental focus and productivity improvement. Last but not least, the contribution of proposed heuristic rule to remanufacturers is to increase awareness of environmental issues in the disassembly line as well as in the productivity itself. The results showed that by applying the heuristic rule the results are good and improve the hazard and environmental factors.

ABSTRAK

Pemulihan produk merupakan topik yang menarik pada masa kini terutamanya dalam industri pembuatan semula. Pengilang memberi tumpuan kepada pemulihan produk kerana bahagian yang bernilai untuk proses pembuatan semula. Pengasingan adalah proses paling penting yang mengasingkan bahagian bernilai atau separa pembuatan bernilai dan bahan daripada produk dibuang. Produk yang dibuang mempunyai tahap ketidakpastian yang tinggi dalam struktur dan kualiti produk yang dipulangkan. Sesetengah bahagian produk boleh menyebabkan pencemaran atau mungkin berbahaya. Masalah Pengimbangan Laluan Pengasingan (DLBP) adalah isu utama yang pengeluar mesti menyelesaikannya semasa proses pengasingan. Objektif penyelidikan ini adalah untuk mengoptimumkan stesen kerja di garisan pengasingan dan meningkatkan penggunaan setiap stesen kerja melalui peraturan heuristik yang dicadangkan. Perisian simulasi Quest Delmia digunakan untuk mengesahkan model antara garis pengasingan sebenar dan peraturan heuristik yang dicadangkan. Model peraturan heuristik yang dicadangkan mengeluarkan hasil yang lebih baik berbanding dengan garis pengasingan yang sebenar dari segi tumpuan alam sekitar dan peningkatan produktiviti. Akhir sekali, sumbangan peraturan heuristik yang dicadangkan kepada pengeluar semula adalah untuk meningkatkan kesedaran mengenai isu-isu alam sekitar semasa garisan pengasingan serta produktiviti itu sendiri. Keputusan menunjukan aplikasi heuristik yang dicadangkan adalah lebih baik dari risiko fakta persekitaran dan bahaya dapat dikurangkan.

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LIST OF EQUATIONS

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3.3 $NT = OTxPR$

3.4 $ST = NTxAF$

3.5 $AF_{job} = 1 + A\mathrm{j}$

3.6 $AF_{day} = \frac{1}{1-A}$

LIST OF SYMBOLS AND ABBREVIATIONS

a	Desired accuracy percentage
A	Allowance percentages based on workday
AC	Air Conditioning
AF	Allowance Factor
ALB	Assembly Line Balancing
ALBP	Assembly Line Balancing Problem
ARA	Automotive Recycler Association
ASR	Automotive Shredder Residue
CT	Cycle Time
CKD	Complete Knock Down
DLBP	Disassembly Line Balancing Problem
EOL	End of Life
ELV	End-of-Life-Vehicle
EPA	Environmental Protection Administration
EU	European Union
HRRCD	Hazard-Reuse-Recycle-Collected-Disposed
MAARA	Malaysia Automotive Recyclers Association
MARN	Malaysia Automotive Recycling Network
MIP	Material In Progress
MIROS	Malaysian Institute of Road Safety Research
n	Number of observations
NT	Normal Time
OT	Observed time
PR	Performance Rating

PTO	Power Take Off
RAT	Rear Axle Transmission
s	Sample standard deviation
SALB	Simple Assembly Line Balancing
ST	Standard Time
T	Task Time
$\bar{x}$	Sample mean
WEEE	Waste of Electric and Electronic Equipment
z	Number of normal standard deviations needed for desired confidence

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CHAPTER 1

INTRODUCTION

1.1 Introduction

"Manufacturing is the process of producing goods for sale by using machineries, equipment, tools, and labors either in primary industries, secondary industries, or tertiary industries" (Groover, 2007). Manufacturing can be defined in two ways, which are technology and economy. For technological, "manufacturing is the application of physical and chemical processes to alter the geometry, properties, and appearance of a starting material to make parts or products" (Groover, 2007). Economically, "manufacturing is the transformation of materials into items of greater value by means of one or more processing and/or assembly operations" (Groover, 2007). Manufacturing will add value to the material by changing its shape or properties, or by combining it with other materials.

The process of manufacturing has created endless values of finished goods to the market and it cause environmental pollution after disposed by consumers. "The end-users are careless about green environment and keep throwing useless goods such as electronic devices, automotive parts, and hazardous parts all over the places. This situation cause more and more manufacturers to recycle and remanufacture their post-consumed products due to insertion of new product, more rigid environment legislation, increased public awareness and extended manufacturer responsibility. In addition, the economic attractiveness of reusing product, subassemblies or parts instead of disposing of them has further fuelled this effort. Recycling is a process performed to retrieve the material contents of used and non-functioning products" (McGovern, 2003a).

Remanufacturing is “an industrial process in which worn-out products are restored to like-new product’s conditions” (McGovern *et. al*., 2003). Thus, remanufacturing provides the quality standards of new product with used parts (McGovern *et. al*., 2003). In order to minimize the amount of waste sent to landfills, product recovery seeks to obtain materials and component from old or outdated products through recycling and remanufacturing. This includes the reuse of components and products. There are many attributes of a product that enhance product recovery such as ease of disassembly, modularity, type and compatibility of materials used, material identification markings, and efficient cross-industrial reuse of common parts/materials. The first crucial step of product recovery is disassembly (McGovern & Gupta, 2004a).

1.2 Background of the research

Disassembly is defined as “the methodical extraction of valuable parts/subassemblies and materials from discarded products through a series of operations. After disassembly, reusable parts/subassemblies are cleaned, refurbished, tested and directed to inventory for remanufacturing operations. The recyclable materials can be sold to raw-material suppliers, while the residuals are sent to landfills” (McGovern & Gupta, 2004a).

Recently, disassembly has gained a great deal of attention in the literature due to its role in product recovery. A disassembly system faces many unique challenges; for example, it has significant inventory problems because of the disparity between the demands for certain parts or subassemblies and their yield from disassembly. “The flow process is also different” (Brennan et al., 1994). As opposed to the normal “convergent” flow in regular assembly environment, in disassembly the flow process is “divergent” (a single product is broken down into many subassemblies and parts). There is also a high degree of uncertainty in the structure and the quality of the returned product. The conditions of the products received are usually unknown and the reliability of the components is questionable. Some parts of the product may cause pollution or may be hazardous. These parts tend to have a higher chance of being damaged and hence may require special handling, which can also influence the utilization of the disassembly workstations. For example, an automobile slated for disassembly contents a variety of parts that are dangerous to remove and/or present a

hazard to the environment such as the battery, airbags, fuel and oil. Various demanded sources may also lead to complications in disassembly line balancing. The reusability of parts creates a demand for these parts, however, the demands and availability of the reusable parts is significantly less predictable than what is found in the assembly process.

Finally, disassembly line balancing is critical in minimizing the use of valuable resources (such as time and money) invested in disassembly and maximizing the level of automation of the disassembly and the quality of the parts (or material) removed (Seamus & Gupta, 2003). As investment in remanufacturing is increasing, optimization is necessary to ensure profitability. Therefore, this research is an attempt to achieve that profitability.

1.3 Problem statement

The Disassembly Line Balancing Problems (DLBP) is commonly found in remanufacturing industries, especially automotive and electronic sectors. Similar to an assembly line, a disassembly line is made up of an ordered sequence of stations often connected by some mechanical material handling equipment. Discarded products enter the disassembly line and move to downstream stations. Disassembly lines can be paced or un-paced. In a paced disassembly line, a set of disassembly tasks is performed at each station within the cycle time common to all stations. As the variability in task times is high, un-paced disassembly lines can be designed. In an un-paced disassembly line, all stations are allowed to operate at their own pace, and therefore subassemblies may wait to step in the downstream station and stations may become idle as they wait the next subassembly from the upstream station. Buffers are placed between stations to partially overcome arising difficulties (Becker and Scholl, 2003).

This research focus on optimization of truck's disassembly line balancing. The benefits of this research are improvement of efficiency of truck's disassembly line. The CKD (Complete Knock Down) trucks imported from Japan have bundle of problems especially parts condition. The engineers are responsible to inspect all parts from a truck in fully disassembly condition. It take time to finish the whole process. At the same time, the engineers unaware that some parts have hazardous contents such as solvent, vapor from air-condition, and other chemical contents. Therefore, this

research is investigate effectiveness of disassembly line in term of time, parts considerations, and environmental concern on parts.

1.4 Research questions

(i) What is the current line efficiency of the disassembly line in fully dismantle truck process?

(ii) What heuristic rule that takes with consideration of environment and hazard that can be applied to optimize the process of disassembly line?

(iii) How to optimize the efficiency of the disassembly line that consider hazard and environment by applying a new proposed heuristic rule?

1.5 Research objectives

(i) To study and optimize the workstations in a truck disassembly line taking into consideration of its complexity.

(ii) To balance and improve efficiencies of the truck disassembly line through normal line balancing methods by minimizing its idle time.

(iii) To develop a novel improved heuristic HRRCD rule for a disassembly line and evaluate its efficiencies.

1.6 Scope of the research

The scopes of the research are as follows:

- According to Malaysia Automotive Recyclers Association (MAARA), they are several organizations involve in trucks rebuilt and recondition processes.

- The partners of MAARA are collaborate with this research confidentially that to find out improvement in disassembly process. Most of the partners are involve in truck disassembly process, especially 6x4 commercial trucks.

- This research investigate 6x4 commercial trucks, with specifications of V8 diesel engine, trucks branded HINO, without turbo charger, and it's strictly imported from Japan.

- The stop-watch is used as the tool to record time study of truck's disassembly processes.

- Only fully rebuilt trucks involves in this research.

- Only CKD (Complete Knock Down) trucks involves in this research.

- The Delmia Quest computer-based software is used to validate the truck's disassembly processes.

1.7 Significance of the research

The Malaysian Automotive Recyclers are limited to truck's rebuilt industries. It involves large resources and mechanisms, especially financial stress in tendering is a significant challenge for recyclers. The concept of optimization is gaining popularity in truck's remanufacturing industry and this means achieving savings not only in economic term, but also through environmental care and social responsibilities.

They are a number of outcome that this research obtained from truck's disassembly line as follows:

- This research seeks to add new knowledge by filling the gap between optimization of disassembly line and environmental care in the context of truck's remanufacturing. The data collected is an asset to knowledge in this area. The research findings serve as the guidelines to encourage optimization disassembly line and environmental care for stakeholders.

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